I.J.E.M.S., VOL.6 (1) 2015: 19-22 ISSN 2229-600X

INTERNATIONAL JOURNAL OF ENGINEERING AND MANAGEMENT SCIENCES

www.scienceandnature.org

OBSERVATION OF INTRUSIONS IN SEISMIC REFRACTION SURVEYS (A CASE STUDY OF AFIKPO)

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ABSTRACT
A siesmic refraction survey was carried out in Afikpo, Nigeria with the aim of observing intrusives within the area. Afikpo is a sedimentary area situated within latitude 5^0 52′-5^0 57′ N and longitude 7^0 52′- 7^0 58′ E. It has an area of about 50km. The survey was conducted using a portable MOD S79 3-channel digital type signal enhancement seismograph along with P-wave sources. Hence, only P-waves were generated and utilized. A total of ten seismic spreads were carried out. Analysis of the seismic refraction data obtained revealed the presence of intrusive in one of the locations. The result shows that the average compressional wave velocity for the first three layers in this location are 442m/s, 2461m/s and 4530m/s respectively. The topmost or first layer with a thickness of 6.7m was interpreted to be made up of sandy clay. The second layer which was interpreted to be sand with gravel, had average thickness of 12.9m. The third layer having a mean velocity of 4530m/s is suspected to be a layer of intrusions.

KEYWORDS: Refraction, Sedimentary, Compressional, Seismic.

INTRODUCTION

When molten magma is released from the earth's interior during a volcanic eruption, some of it reaches the earth's surface where the temperature is relatively low and they solidify there as hard rocks; these are technically called extrusive rocks. The magma which could not get to the surface before solidifying are the intrusive rocks or simply intrusives. In a sedimentary area, the compressional (P) wave velocity of such rocks are quite high in contrast to those of sedimentary structures which have lower seismic velocity. Intrusives can be mapped with the seismic refraction method. This work aims at observing intrusives in Afipko (a sedimentary area) using seismic refraction method. This method involves the utilization of the propagation paths of seismic waves (compressional or shear or both). The waves travel with different speeds in different media. This behaviour of the waves is useful among other things in mapping near-surface intrusions.

There has been some earlier geophysical surveys carried out in Afikpo. Agha et al (2006) conducted a seismic refraction survey with the objective of determining the strength of foundation materials in the area. They used a signal enhancement seismograph and its accessories including P- and S- seismic sources and detectors. Their results showed that the mean seismic velocity of the first and second layers of the area were 370m/s and 1060m/s. The mean Poisson's ratio values for these first two layers were 0.16 and 0.23 respectively. These gave mean values of shear modulus (μ) as 0.4 and $3.4x10^9 N/m^2$, Bulk modulus (k) as 0.07 and $1.5x10^{10} N/m^2$, and Young's modulus (E) as 0.8 and $9.5x10^9 N/m^2$ for the first and second layers respectively.

LOCATION AND GEOLOGY OF STUDY AREA

Afikpo, the study area is located within the south – eastern part of Nigeria and lies within latitude 5^0 52′-5^0 57′ N and longitude 7^0 52′- 7^0 58′ E (Fig. 1). It has a total land mass of $50km^2$. Afikpo is a sedimentary terrain. It is an integral part of the Benue trough whose basin extends over 800km from the Niger Delta basin to the southern margin of the Chad basin. The area contains three main geological formations (Fig. 2). From the east to the west and in terms of age and sequence of exposure, the formations are (i) Asu River group of the Albian age (Lower Cretaceous) made up of shales, sandstones and siltstones of which sediments later became folded giving rise to the Afikpo synclinorium. (ii) The Ezeaku formation of the Turonian age containing shales, siltstones, sandstones and limestones; this has the same age with the Afikpo sandstones. (iii) The Nkporo shale formation (Kogbe, 1989).

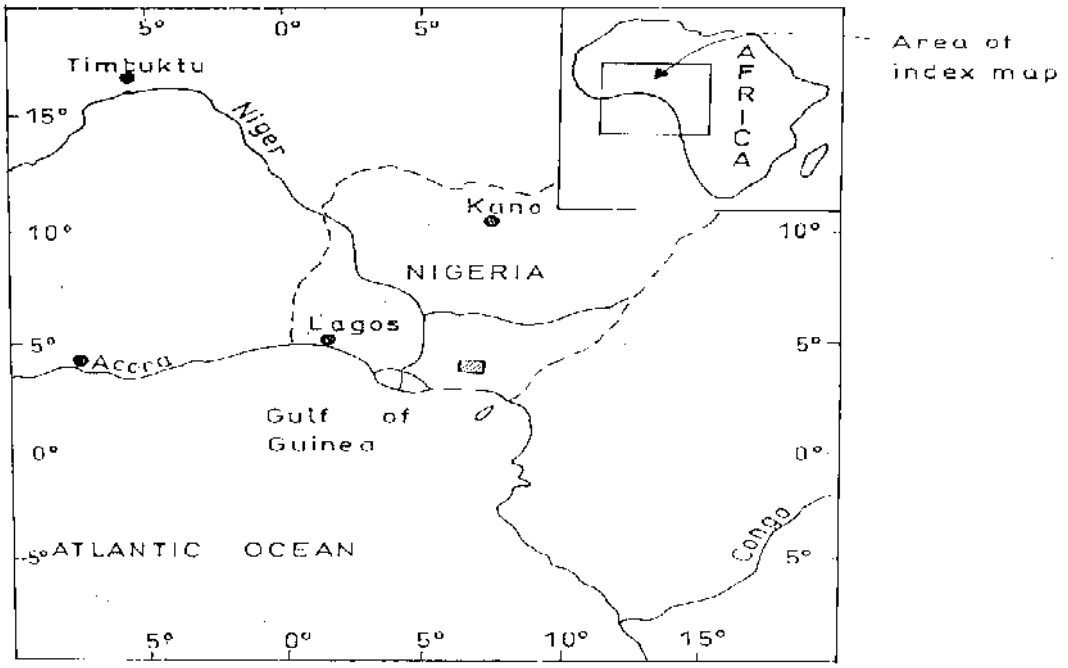

Fig. 1: Location Map of StudyArea

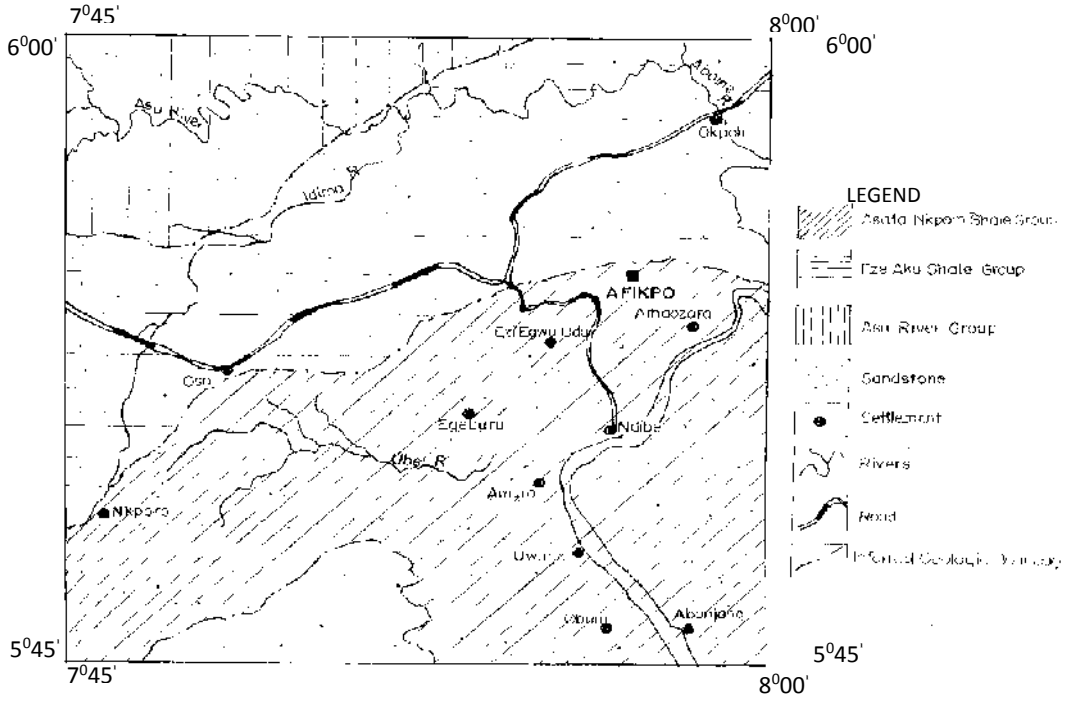

Fig.2: Geological Map of Study Area (Afikpo)

MATERIALS

A portable MOD S79 3-chanenel digital type signal enhancement seismograph is the major equipment used for this survey. The instrument is designed to acquire seismic data from a source with the three channels at the same time. An integral part of the seismograph is the signal enhancement device which serves to improve the signal to noise ratio with a hard copy option for production of seismograms. Also within the seismograph are facilities for automatic gain control and trace size adjustments which increase the trace size of displayed signals on the screen.

Included within the system also is a DPU 411 type II thermal printer. The MOD S79 seismograph is powered by an in-built 12V accumulator with an operating time of about thirty (30) hours. Some other components of the instrumentation for this refraction work include aluminum striking plate and 9kg sledgehammer as seismic source and P-wave geophones/detectors.

METHOD

Refraction profiling can be carried out in various scales. For refraction survey on a small scale such as this one (mapping near surface intrusive), values of travel times for records up to an offset distance of 40m may be sufficient. The energy to traverse the short recording range comes from a simple weight-dropping device (in this case, a 9kg sledgehammer) impacted upon a steel plate.A total of ten seismic refraction surveys were carried out. The inter-station spacings were not fixed-sometimes there were as much as 800m and at other times only 100m. Four traverses were alligned in the S-W direction, another four in the E-W while two had a NESW orientation. The length of each traverse was 40.5m but the geophones were interspaced by 4.5m.

The metal plate was buried to a depth of 5cm in the ground. This was to ensure deeper penetration of seismic energy when the plate is struck with the sledge-hammer and also for better coupling.

RESULT

The arrival times, T(ms) of the seismic waves propagated through the earth were obtained for given offset distances of sensors from the source of energy. These times, T in milliseconds of both the forward traverse(TF) and the reverse(TR) and the corresponding offsets, X in meters are presented here for just one location(the location where intrusions were observed). The tabulated data (Table 1) and the corresponding T-X curves (Fig. 3) are shown below.

Table 1: Refraction T-X data (forward and reverse) for compressional wave propagation in one of the locations in the study area.

X(m)	TF(ms)	TR(ms)
4.5	9	6
9.0	20	15
13.5	26	16
18.0	28	25
22.5	32	31
27.0	34	35
31.5	38	38
36.0	39	39
40.5	40	41

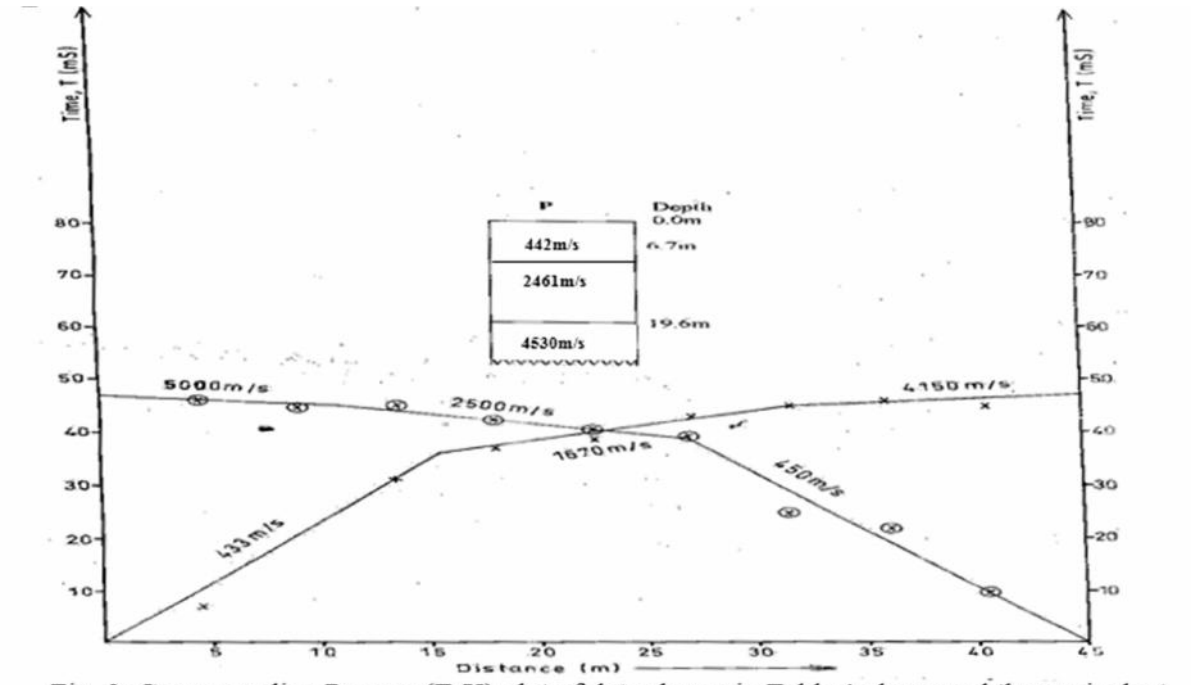

Fig. 3: Corresponding P-wave (T-X) plot of data shown in Table 1 above and the equivalent geo-seismic layers of the concerned location.

INTERPRETATION

Fig. 3 above shows that the P-wave utilized in the study encountered a 442 m/s top layer, probably sandy clay, 6.7m thick, which overlies a 12.9m thick consolidated layer, probably composed of sand with gravel with a mean velocity of 2461m/s. This layer was in turn underlain by a much consolidated layer with average velocity 4530m/s suspected to be an intrusive. The dips of the first and second layers were 13^0 and 6^0 respectively.

SUMMARY

Considering the results of this study, we summarize as follows.

i. There had been volcanic eruptions in the study area. This is evident in the geologic history of the area.
ii. Magmatic intrusions could probably not have occurred everywhere in the area as only one out of the several locations surveyed revealed the possible presence of intrusions.
iii. Intrusions may have taken place in other parts of Afikpo but at very shallow depths than seismic energy generated could reach.
iv. Given the seismic wave velocity of the intrusives encountered in the study, it is suspected that the intrusives in the area could be granites(Dobrin and Savit, 1988).

CONCLUSION

Near - surface intrusive are present in the study area. The intrusions which were encountered at a depth of 19.6m have an average seismic velocity of 4530m/s and are likely to be granitic.

RECOMMENDATION

The type of seismic energy source utilized in the survey might have imposed a limitation on the depth of observation of the intrusives of the area. Perhaps, intrusions could have been also observed in some other parts of Afikpo but for the mechanical impact source of energy employed. We therefore recommend the use of fibrosis or dynamite as energy sources to future researchers.

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